yet incapable of exact control; errors which are small but yet significant in the light of the magnitude of sugar transactions.

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SPECIAL ARTICLES.

A BURIED TREASURE OF ECONOMIC ORNITHOLOGY.

In 1865 there was published in New York a work on entomology by Dr. Isaac P. Trimble. Though dealing primarily with insects, the book contains the most original and accurate observations then made in economic ornithology in America. Concealed under its caption, 'A Treatise on the Insect Enemies of Fruit and Fruit Trees,'[1] is a mine of information concerning the relations of birds to some of the worst pests horticulture has to endure.

The attention to minutiæ and the scientific accuracy with which the data were gathered are remarkable for the time, and the line of investigation, undeveloped as it was. While Samuels, Michener, Flagg, Bryant, Jenks and others were working in the field of economic ornithology at that or a little earlier period, the work of few, if any of them, is marked by the wealth of definite information that characterizes the labors of Trimble.[2] His specific identifications of substances found in the stomachs and his technique of determination savor strongly of present methods, and at once distinguish his work from most of the contemporaneous articles on the subject, being, as often they were, mere compilations of Audubonian and Wilsonian phrases.

Dr. Trimble went to the birds themselves for his information. He says:

I have killed a very large number of birds and examined the contents of their stomachs, especially of those frequenting orchards. Most of these examinations have been made with a magnifying glass, and many with the microscope. Some species I have shot at short intervals during the season, to know how far their food varied at different times; and I have thus ascertained that the contents of the stomach at any one time are not an infallible criterion by which we can determine the usual food of that bird. On the fifth of May, 1864, I shot seven different birds; they had all been feeding freely on small beetles, and some of them on nothing else. There was a great flight of these small beetles that day; the atmosphere was teeming with them. A few days after the air was filled with ephemera flies, and the same species of birds were then feeding upon these (p. 113).

Here he recognizes the law that birds as a rule feed upon substances most abundant about them, a fact with which we are constantly brought face to face in the more extensive investigations of the present time. Continuing the comparison, as we identify some beetles by the scutellum or chrysalides by the cremaster, he also had his little niceties of method, of one of which the following is an interesting description:

The eyes of most insects are wonderfully formed. They may be said to be compound eyes, each made up of many hexagonal lenses. If a comb of the hive bee, containing one or two hundred cells, could be photographed down to the size of the head of a pin, it would look somewhat like the eye of a beetle. Each eye of the Curculio contains about 150 of these lenses. The number in the eyes of butterflies, moths or dragonflies amounts to many thousands. In some microscopic experiments made last summer upon the eyes of plant lice from different trees and plants, it was found that the number of lenses in the eyes of these insects varied from every tree and plant. Each thus proved to be a distinct species, no matter how close the resemblance in other respects. Thus, should the rose bushes of the garden or a neighborhood be cleared of these pests they would not be reinhabited by those from other plants. While examining one of these aphides it brought forth a young one, and this in turn being tested its eye was found to contain the same number of lenses as the mother's. This peculiarity of the eyes of insects, and the knowledge of the exact number of these lenses in the eyes of each species, become

[1] William Wood and Co., New York, 1865, pp. 139, pls. XI. This title is not to be found in Coues's bibliography nor in any list of publications concerning economic ornithology. By entomologists, however, the publication is frequently cited sometimes even for its ornithological matter, and its author is deemed entitled 'to a prominent place with the early economic entomologists of the country.'

[2] The latter says, however, of the work of Flagg, 'Of the many contributions to the history of birds, I have met with none so interesting as this' (p. 113).

important in investigations where only the comminuted parts can be obtained. In a long series of examinations of the contents of the stomachs of birds, for the purpose of ascertaining more positively how far the insectivorous kinds frequenting orchards are useful in feeding upon these enemies of fruits, the microscope has enabled me to demonstrate many facts otherwise difficult to prove (pp. 37–8).

How he made use of the little point about the curculio he describes in a fascinating manner:

Killed an oriole (Baltimore)—a male of one year; it did not have the brilliant colors of the fully matured bird. I followed it from tree to tree for a long time, listening to its peculiar notes, and watching its habit of feeding. In a very careful examination of the contents of the stomach, what appeared to be the wing-cases of a *Curculio* were discovered; and on further scrutiny I found the head with proboscis attached. This was exciting. Here was some evidence that one bird at least was feeding upon our most formidable insect enemy; but as the *Curculio*[3] is one of a large family of the Coleoptera, and many of the different species bear a striking resemblance to each other, both in form and size, it was necessary to pursue the investigation still further. On placing the wing cases under the microscope, the peculiar protuberances—the brilliant metallic colors—the hairs resembling pearls, when a strong light is directed upon them, that I had so often seen, were all visible. The mutilated head was now tested. There was the proboscis with its cutting apparatus, and the 147 lenses in the eye.

I have examined the eyes of many others of this family, but not one of them has the same number of lenses. The larger species figured in Pl. 5, Fig. 10, has more than double this number.

All this evidence taken together was ample to settle this question forever. The Baltimore eats the *Curculio*![4] Let the death of this martyred bird secure the protection of its race for all future time. The remains of three other beetles and three leaf-curling caterpillars[5] were also found in the stomach of this oriole (p. 77).

The Baltimore Oriole Eats the Curculio. Probably many other birds that frequent the orchard in pursuit of food, and feed upon beetles do the same thing; but none of them search it out exclusively. Therefore, good as most of the birds are as consumers of injurious insects, and though the world, for our purposes, would soon become topsy-turvy without them, the birds can not be relied upon to subdue or control the curculio (p. 85).

Here again our author gives an instance that agrees with the results of a much greater amount of study of the food of birds. That is, birds simply act as a check upon insects, sometimes as a minor one, sometimes the chief. Such must always be the case, for obviously no species can continue to exist if it exterminates its food supply.

Dr. Trimble found feathered enemies of another great insect pest, the apple-worm, or codling moth (*Carpocapsa pomonella*). This is the very task at which an entire state (California) set its energies. Indeed the little codling moth demands a good share of the attention of economic entomologists over the whole world. Our author's efforts in searching out birds that feed upon this insect are particularly interesting. He treats the work of the downy woodpecker in this direction in detail and gives a plate (X.) in figuring this bird, the yellow-bellied woodpecker and the chickadee, so that any one, whether he be acquainted with birds or not, can recognize the friends and the supposed enemy. On the same plate is shown some of the downy's work —the exterior of a piece of bark with the little round holes made by the bird's beak, and the inner side of the same showing how straight and true these tunnels were drilled through to the chrysalis of the moth. He found them at this work from September 8 (p. 135) to April 21 (p. 115), and in his accounts of every place he made observations, Dr. Trimble mentions these holes in the bark of the apple trees. Concerning a trip in Morris County, N. J., he says:

[3] His name for the curculio is *Curculio argula* Fabr., which in modern terminology is *Conotrachelus nenuphar*. The larger species he mentions is really on Pl. VI., Fig. 10, and, he explains, was figured from a specimen taken from the stomach of a toad. From stomachs of these animals he says he has often obtained different species of beetles.

[4] Now known to be eaten by many other species of birds.

[5] Tortricina. Also found by Dr. Trimble in the stomachs of the wren and catbird.

Here I was gratified in being able to ascertain how he finds where to peek through the scales of bark, so as to be sure to hit the apple worm that is so snugly concealed beneath. The sense of smell will not account for it. Such an acuteness of one of the senses would be beyond the imagination. Instinct, that incomprehensible something, might be called in to explain to those who are satisfied to have wonders accounted for by means that are in fact only confessions of ignorance. Birds have instincts undoubtedly—so have we; but they are mixed up confusedly with other faculties. Most of the actions of insects are purely instinctive and utterly unaccountable. But the apple moth is not a native of this country—the downy woodpecker is. The bird would not have been created with a special instinct to find the larva of a moth that did not exist in the same country. Other insects live under these scales of rough bark; but in very numerous examinations, I have not seen such a hole made except when leading directly into the cocoon of this particular caterpillar. This little bird finds the concealed larvæ under the bark, not from any noise the insect makes; it is not a grub of a beetle having a boring habit, and liable to make a sound that might betray its retreat, in seasons of the year when not torpid. A caterpillar makes scarcely an appreciable noise, even when spinning its cocoon, and when that is finished it rests as quietly within as an Egyptian mummy in its sarcophagus.

There is no evidence that the downy woodpecker ever makes a mistake; it has some way of judging. The squirrel does not waste time in cracking an empty nut. There is no reason to believe that this bird ever makes holes through these scales merely for pastime, or for any other purpose except for food. He knows before he begins that if he works through, just in that spot, he will find a dainty morsel at the bottom of it, as delicious to him as the meat of the nut is to the squirrel. But how does he know? By *sounding* —tap, tap, tap, just as the physician learns the condition of the lungs of his patient by what he calls percussion.[6] The bird uses his beak, generally three times in quick succession—sometimes oftener; then tries another. Watch him. See how ever and anon he will stop in his quick motions up and down, and give a few taps upon the suspected scale, and then test another and another, until the right sound is communicated to that wonderful ear (pp. 116–7).

Besides studying the downy woodpecker in the field he examined the stomachs of three of them. One contained *a codling moth larva* and some beetles. Another held one beetle, the heads of *two codling moth larvæ* and of three small borers. The third contained beetles and grubs unidentified.

The black-capped chickadee was also found to feed upon the codling moth. Three specimens were examined, one having eaten eggs of lepidoptera and beetles, another four seeds and a number of 'pupæ of very small beetles, such as take shelter under moss and old bark on trees,' while in the stomach of the third were *five larvæ of the codling moth.*

One of these had been so recently taken, and was so little mutilated, that it was easily identified. The heads of the other four appeared identical when examined with a pocket-glass; but when subjected to the test of the microscope, there was no possible room for doubt. The day had been dry and windy, following a warm wet day and night; and it is in just such weather that the bark of the buttonwood, shellbark hickory, and other shaggy trees, will be found curling out and falling off.

I have never seen anything that would lead me to believe that this minute bird makes the holes in the scales of bark that lead directly to the cocoons of these caterpillars; they are made by the downy woodpecker, and probably by it alone. The chick-a-dee most likely finds these worms only or chiefly on such days as this, when the warping of these scales exposes them to the prying eyes of these busy little friends. This bird is one of the guardians of the orchard; quick, active, always on the alert; assuming any position; sometimes hanging by one foot on the under side of the large limbs, where these caterpillars rather prefer to conceal themselves; and now proved to feed freely upon the second in importance of the insect enemies of our fruits. Let no one hereafter kill a chick-a-dee without being made to feel that he has done a most disgraceful deed (p. 120).

In further proof of their good work he says:

For several mornings in succession I noticed that the piazza was strewn with the cocoons and broken pupa cases of the caterpillars (species?) that were so numerous in September; sweep them off, and soon they would be there again. It was the work

[6] This description of the woodpecker's search for food bears a remarkable resemblance to a forty-years later (1905) account of a percussion process (Perkussionsverfahren) by a German investigator, Dr. Wilhelm Leisewitz.

of the chick-a-dees. The piazza is a high one, and extends on three sides of the house. Hundreds of caterpillars formed their cocoons in the chinks and crevices of the ceiling, and there the little birds found them (p. 121).

Among notes on other birds which he had studied, but which were not found to destroy either of the insect pests he treats, is quite a long dissertation upon the yellow-bellied woodpecker. After watching one drilling holes in an apple tree for some time, he wrote the following:

I shot this poor bird, expecting to find positive evidence in the stomach of what it made these holes for—and found two seeds or pits[7] (of which one and half the other are represented in Fig. 9, Plate 10), with the purple skins of the same fruit, seven small ants, and one insect of the chinch bug kind about the size of those found in the beds of some taverns. But of bark or sap there was not even a trace.

Later in the day I shot another of the same species of bird in an old orchard out of town. The stomach of this one contained the pulp of an apple and one ant—nothing else. This one was on the upper part of an apple tree, and was not pecking or sounding. The investigation of this bird so far is unsatisfactory. I have seen no evidence yet that these holes are made in search of food. Ants are certainly found sometimes about these holes, and apparently in pursuit of the sap that exudes from them; but the idea suggested by some, that the birds make them to attract these ants by such tempting baits, is a palpable exaggeration of the reasoning power of this bird (p. 118).

Notwithstanding the subsequent great increase of knowledge in regard to birds, the puzzling problem of the sapsucker is in almost as unsatisfactory a state at the present as when Dr. Trimble was making his pioneer investigation.

In the case of some other birds, also, of whose status we are none too sure, the author's treatise presents data. Among such birds are warblers and creepers, mentioned in the following paragraph:

The season of 1864 will be memorable as the year of aphides, or plant lice. The first crop of leaves on many of the apple trees was so alive with a species of these pests that most of them fell off, causing also a profuse shedding of the young apples. Warblers of many kinds, then just coming on from the south, creepers, wrens and even sparrows, as well as many other kinds of birds, fed upon these the livelong day. The throats, and even the back parts of the beaks of some of them, would be found lined with these aphides, many of them still alive, and their stomachs containing a juice that would leave the hands colored as they are after crushing these insects. The creases or folds of the stomachs were lined with what appeared to be an accumulation of the hairs of caterpillars, but under the microscope were found to be the legs of these plant lice—thousands and thousands of them (p. 114).

From stomach examination he learned, also, that the bobolink eats cankerworms. "I have found his stomach filled to repletion with these troublesome caterpillars" (p. 114). The same pests he finds are eaten by another bird.

I have found as many as thirty-six young canker worms in the stomach of one (cedar-bird), and I have known companies of these birds come after a species of canker worm on a cherry tree, several times every day, for two weeks, during the last summer; and when I saw them afterwards feeding upon the cherries, I felt that they had saved the crop, and were entitled to a part of it. This and several other species of birds are very troublesome to grape as well as cherry growers, and I know men who are threatening to shoot them next year. But there are two sides to this question. The grape crop would be a precarious one if its insect enemies were not kept in check, and there is no protector so efficient as the birds. Save your cherries and grapes if you can, but better lose a large portion than kill the birds (p. 26).

In the stomachs of meadow-larks he found oats and wheat and thousand legs (*Julus*), and in one of a crow shot in February a few beetles and about fifty grasshoppers.

Some of these, he says, were of the variety so plentiful late in fall, but the greater part were of that kind that we find in the spring about half grown, and not yet having their wings matured—such as are at full size in July. Many do not know that grasshoppers live through the winter; many do not know that crows eat insects. The farmers, when they see flocks of crows ransacking their fields and meadows, instead of offering bounties for their destruction, should be thankful

[7] Judging from the illustration these are evidently the seeds of the dogwood, *Cornus florida*.

that there is something to keep the grasshoppers and other insects in check (pp. 101–2).

The statements in this paragraph seem eloquent of the spirit of the man. He found out many things that others did not know and strove after a genuine appreciation of the relations of things about him. He was one of the earliest to take the direct method of doing this in the field of American economic ornithology. That his work has remained unnoticed because of a name is a pity. His observations are not trite to-day, but, on the contrary, they possess freshness, almost novelty. That such is the case after a lapse of more than forty years is a significant tribute to an able and original man.

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GALL-INSECTS AND INSECT-GALLS.

In no phase of biological work are the results of the neglect of cooperation more apparent than in the study of 'insect-galls' and 'gall-insects.' In fact many of our best scientists fail to recognize the two closely related subjects as distinct and continue to use the terms synonymously, although the one is botanical while the other is entomological. The entomologists have given considerable attention to the study of gall-insects, but the study of insect-galls has been woefully neglected, while lack of cooperation has made much of our entomological knowledge of questionable value.

For some time the writer has been bringing together the literature upon these two subjects, and it may be of interest to the readers of Science to see a summarization of the work in hand at this time. The six orders of insects containing gall-makers, include 16 families, 77 genera and 583 species (not counting leaf curlers and those for which galls have not been described, but which we have every reason to suppose are true gall-makers). These galls arranged with reference to the host plants show the following: 26 orders, 51 families, 90 genera and 188 species affected. Of the 26 orders 12 show only one family in each to be affected; of 51 families 26 have only one genus affected; of the 90 genera 63 have only one species in each affected. The genus *Quercus* leads with 45 affected species and *Salix* is second with ten affected species.

These figures are absurd and every student of either entomology or botany believes that the list of host plants should be much longer.

Let us look for an explanation: (1) The botanist has given practically no attention to the subject, although every herbarium of importance contains more or less galls that have been incidentally collected. (2) The entomologists have studied the insects rather than the galls and too often their descriptions of the galls have been indefinite. Furthermore, the determinations of the host plants in many cases have been uncertain or entirely omitted. Papers have been published without giving the common names of the hosts, others with only the common names, others with only the generic names and others in which it is evident that the determinations are incorrect. A well-known botanist in examining my list recently remarked: 'Here you have a number of galls attributed to a single host plant, while I have seen galls on four different species of that genus.' Yet, I have reason to believe that I have examined practically all the North American literature on the group of gall-formers to which he referred. I have also received from well-known entomologists, galls of the same species bearing different names.

The study of the insect-galls and their makers, parasites and inquilines presents a very large number of interesting problems of which the following may be mentioned: (1) We know very little concerning the dimorphism of the American species. (2) We know nothing of the relation of the distribution of the insect, to the distribution of the host plant. (3) We have very little reliable data concerning the ability of any one species of insect to produce galls upon more than one species of host plants. (4) Very little has been done on the anatomy of the American galls. (5) Very little has been done on the physiology of the galls.

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